more recent remarkable studies by Teisserenc de Bort and his collaborator, Hildebrandsson.[5]

In fact the extent to which atmospheric circulation depends on oceanic conditions, when once fully recognized, will make a close cooperation between meteorologists and oceanographers a condition sine qua non for the formulation of successful weather forecasts.

THE INFLUENCE OF THE OCEAN ON RAINFALL.

From a theoretical point of view the prevailing conditions of the surface sheet of the ocean ought to have a decided influence on the amount of rain precipitated over the continents. However, so far no very definite proofs have been produced for the actual existence of the supposed relationship. The greatest part of the rain which falls over Europe is no doubt formed by evaporation from the surface of the North Atlantic. Now the rate of evaporation, which is a function of several variables, varies rapidly with temperature, a rise of 5 degrees from +10°C. to +15°C. corresponding to an increase in the vapor pressure of some 40 per cent. It would therefore appear very likely that an unusually low surface temperature over large parts of the North Atlantic may be followed by a reduced rainfall in a coming season. O. Pettersson[6] has proved that at times when an outburst of icebergs takes place in the South Indian Ocean the monsoon rains over India will, in general, be very scanty, which inevitably results in a more or less complete failure of the crops and subsequent famine among millions of human beings. The greatest outburst of icebergs in the South Indian Ocean occurred in 1895–1897, and 1896 was a year of exceptional drought in India; the crops there failed over several hundred thousand square miles and millions of the population were reduced to a state of famine.

Once we have full knowledge of the surface temperature (and the salinity) of the most representative parts of the North Atlantic Ocean, and can follow their variations from month to month, perhaps a kind of long-range forecast of the rainfall also may become feasible.

I have tried to point out that from the standpoint of the meteorologist a systematic and regular observation of the North Atlantic is a task which ought to be undertaken without delay and that it would have every prospect of gaining results of immense practical value to mankind.

In a succeeding paper I intend to give brief descriptions of some novel instruments and methods which make it possible to take isolated or continuous observations of various oceanographical elements with a minimum of labor and a high degree of accuracy.

PRECIPITATION OVER THE SOUTHEAST ROCKY MOUNTAIN SLOPE.[1]

By CLEVE HALLENBECK, Assistant Observer.

[Dated: Weather Bureau, Roswell, N. Mex., June 14, 1916.]

Nearly all of the general rains over the region embracing eastern New Mexico and the extreme western portion of Texas come with easterly winds. The greatest frequency of precipitation at the eastern border of this area is with southeast winds, gradually shifting to northeasterly by the time the Pecos Valley in New Mexico is reached. It can be said that in this region rains coming from any other directions than southeasterly and northeasterly are so infrequent as to be negligible.

It follows that any distribution of pressure giving rise to steady easterly winds over this region will be productive of precipitation. The most dependable condition is a low pressure area to the south; in general, south of the 35th parallel of latitude. Precipitation usually begins when the low has moved far enough eastward to bring the incurving winds from the Gulf over west Texas as easterly and over eastern New Mexico as northeasterly winds.

While these lows moving along the southern border nearly always produce precipitation, those that pass north of the 35th parallel seldom cause precipitation over this area. This is due to the topography of the Southwest. The Continental Divide, extending southward from Colorado, divides in northern New Mexico into two branches; the west branch extends southwestward nearly to the corner of the State, while the east branch extends southward, separating the Grande and the Pecos Valleys. The Divide has an elevation of 10,000 to 12,000 feet in the northern part of the State; through the central and southern portions of the State the two branches have about the same elevation of 8,000 feet. The eastern branch, however, extends down into Texas to the meeting of the Grande and Pecos, and thus becomes a controlling factor in the distribution of precipitation over this area. That part of Texas lying immediately east of this range is the dryest portion of the State.

Westerly winds over Arizona and New Mexico are "upslope" winds until they reach the western branch of the divide, then their direction averages about horizontal until they pass the crest of the eastern branch, after which they are "downslope" as long as their direction has an eastward component.

Taking now the case of a depression centered near the northern border of the State: over its western quadrant, the winds are generally "upslope," and therefore favorable to precipitation. Also over its southeastern quadrant the wind is moving "upslope" from the Gulf. But over that portion of its southern quadrant lying east of the divide and west of the belt of southeasterly winds from the Gulf is the area embracing eastern New Mexico and extreme western Texas, where the wind is blowing "downslope," and therefore is unfavorable to precipitation. For this reason, a storm area passing eastward approximately along the northern border of the State causes general precipitation over all the area under its influence, with the exception of this "dry belt."

The accompanying chart (fig. 1, XLIV–72) shows an ideal wind circulation around one of these depressions. The precipitation areas of many LOWS show remarkable conformity to this theoretical one.

A large number of the southern LOWS are southern centers of low troughs. But even in depressions that are regularly formed, there seems to be a strong tendency of the Gulf winds to blow in from the southeast, often blowing in a straight line, or even recurving slightly to the north, when the low center is located as shown on the theoretical circulation. On the chart presented this tendency is emphasized to show the wind-shift line, which normally marks the western limit of precipitation.

The distribution of precipitation around a depression is illustrated in the four composite maps presented in figures 2, 3, 4, 5. These were constructed from the average data for a number of LOWS in approximately the same positions, and show the average pressure, wind direction, and precipitation frequency for LOWS cen-

---

[5] See their work "Centres d'action de l'atmosphère."
[6] Svenska Hydrografisk-Biologiska Kommissionens Skrifter, V.
[1] Accompanied by Charts XLIV–72 to XLIV–76. Figures 1 to 9.

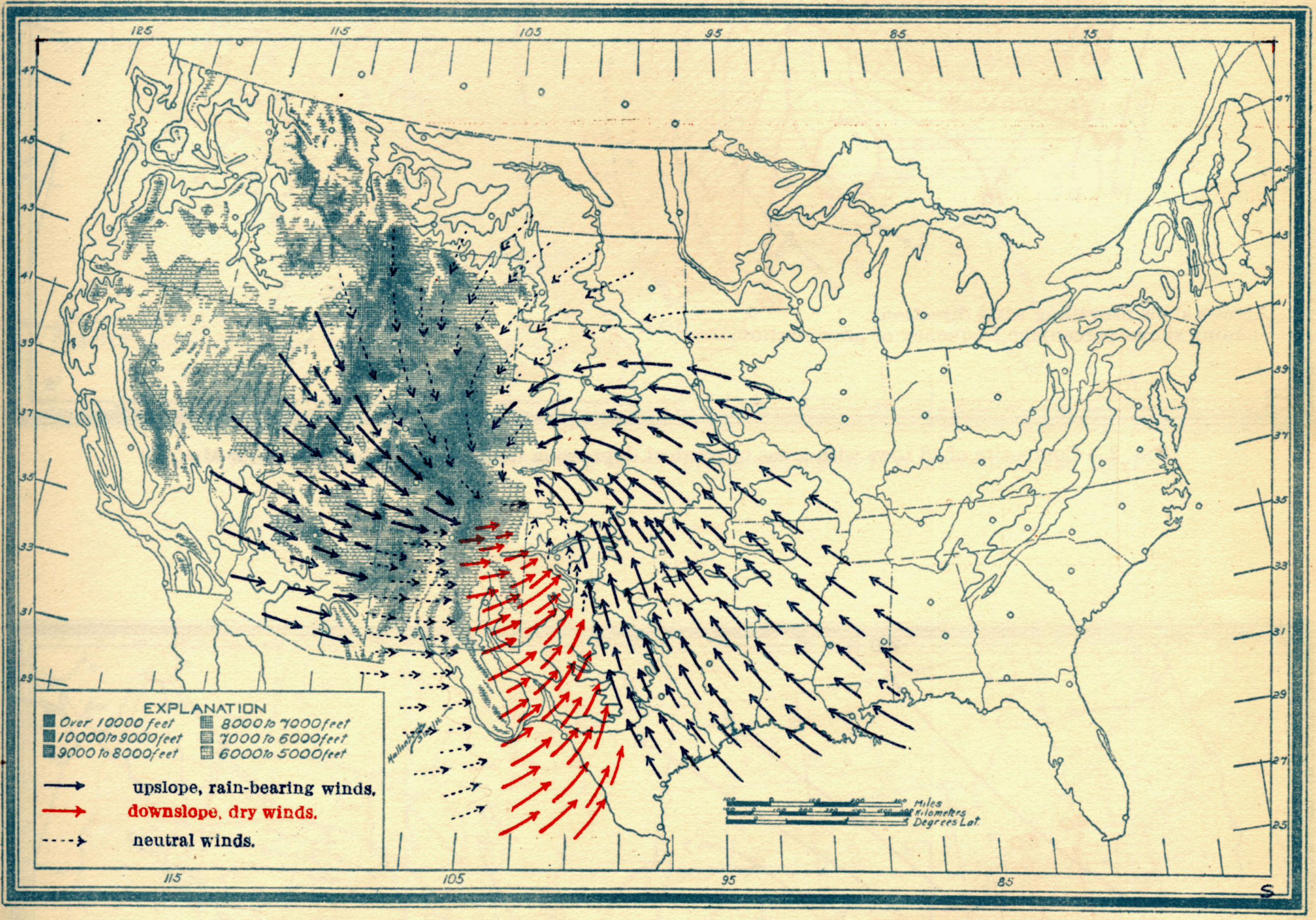

FIG. 1.—Ideal surface circulation about a LOW centered near northeastern New Mexico.

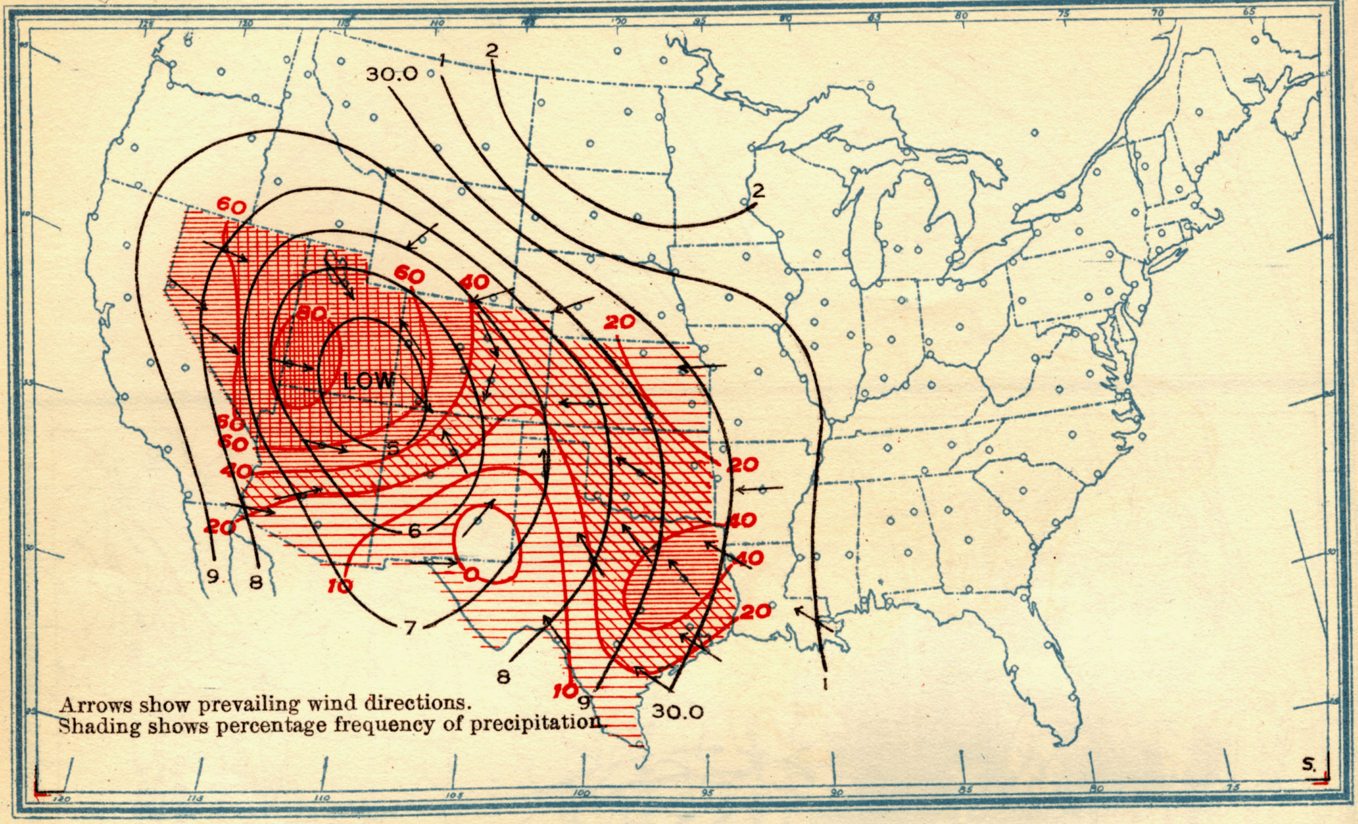

FIG. 2.—Composite of 13 LOWS with areas of greatest depression tangent to northwestern New Mexico.

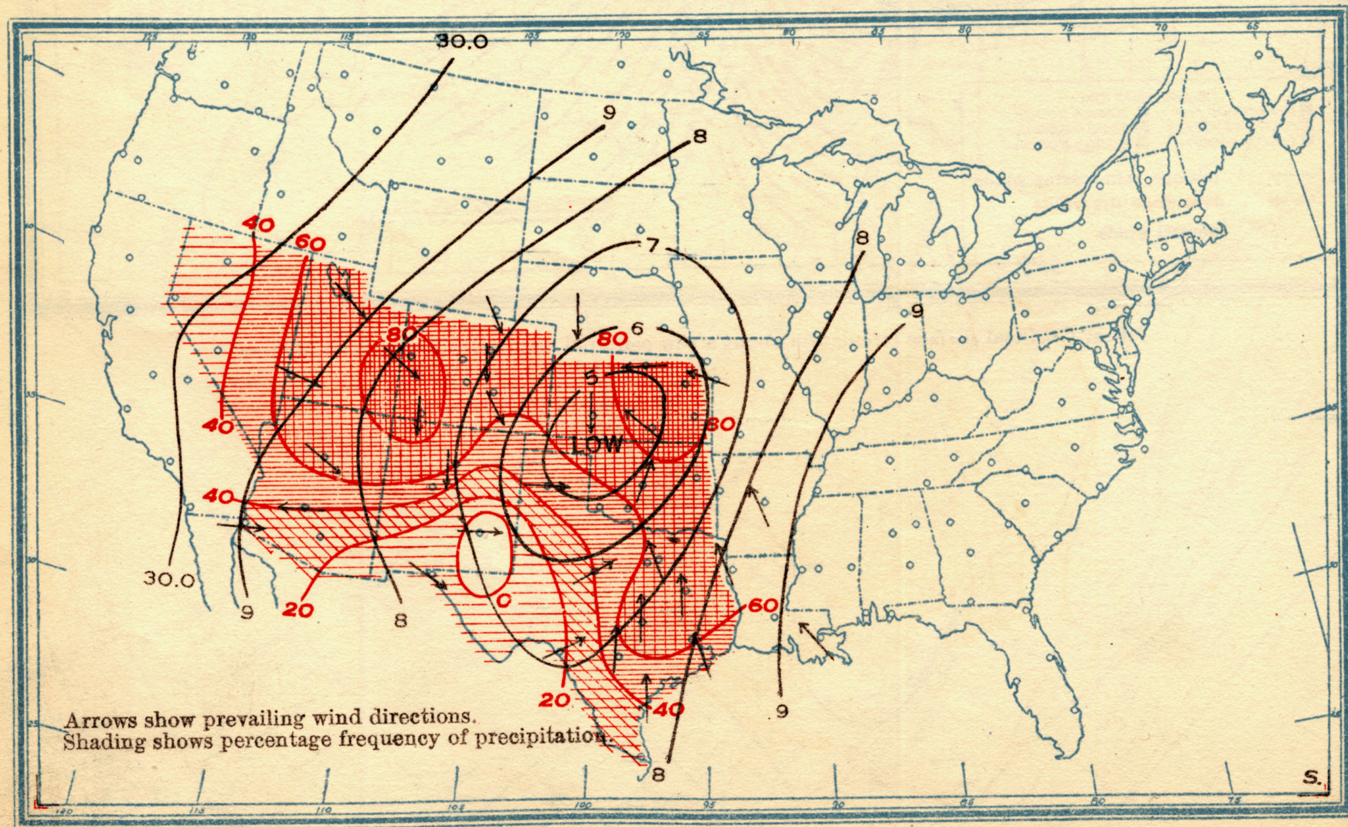

FIG. 3.—Composite of 10 LOWS with areas of greatest depression tangent to northeastern New Mexico.

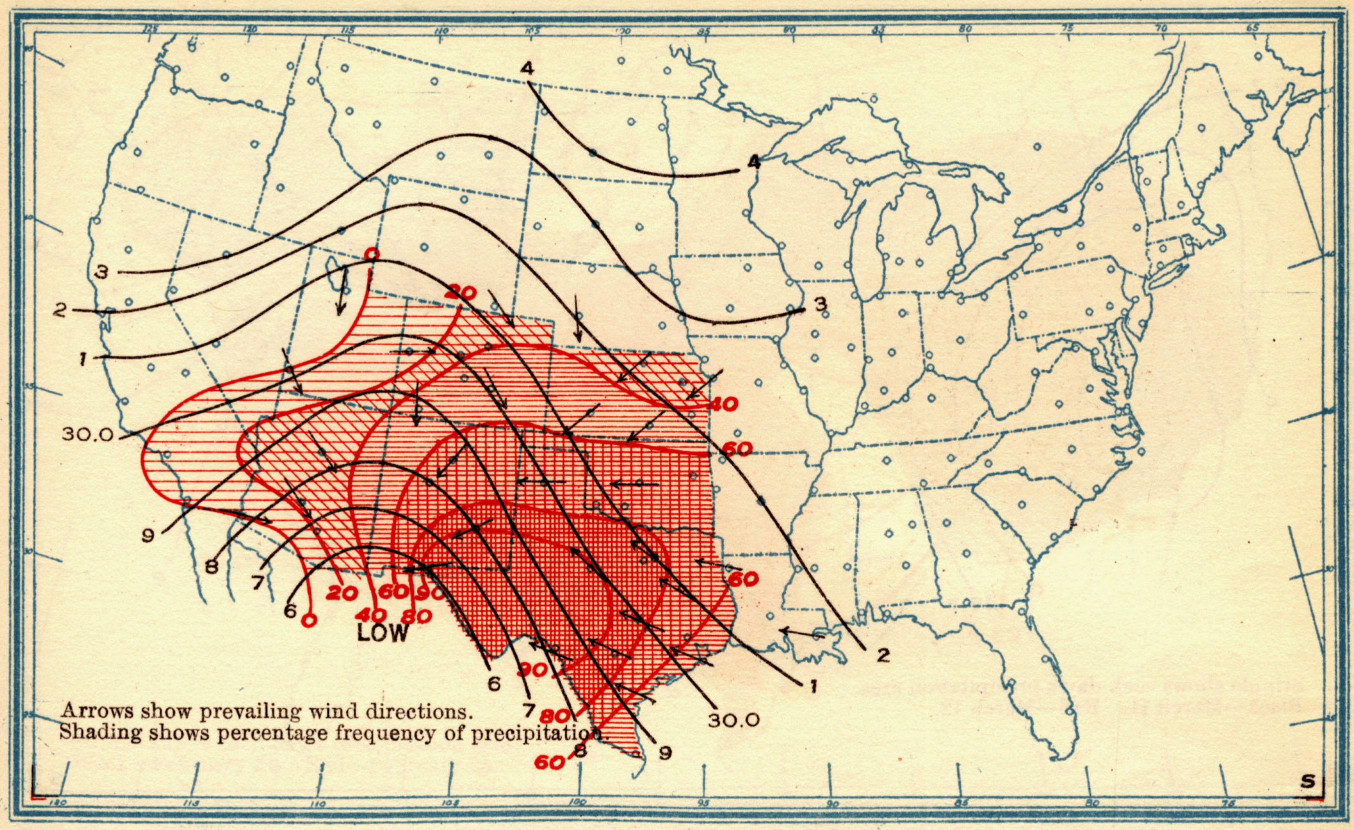

FIG. 4.—Composite of 10 LOWS with areas of greatest depression tangent to southwestern New Mexico.

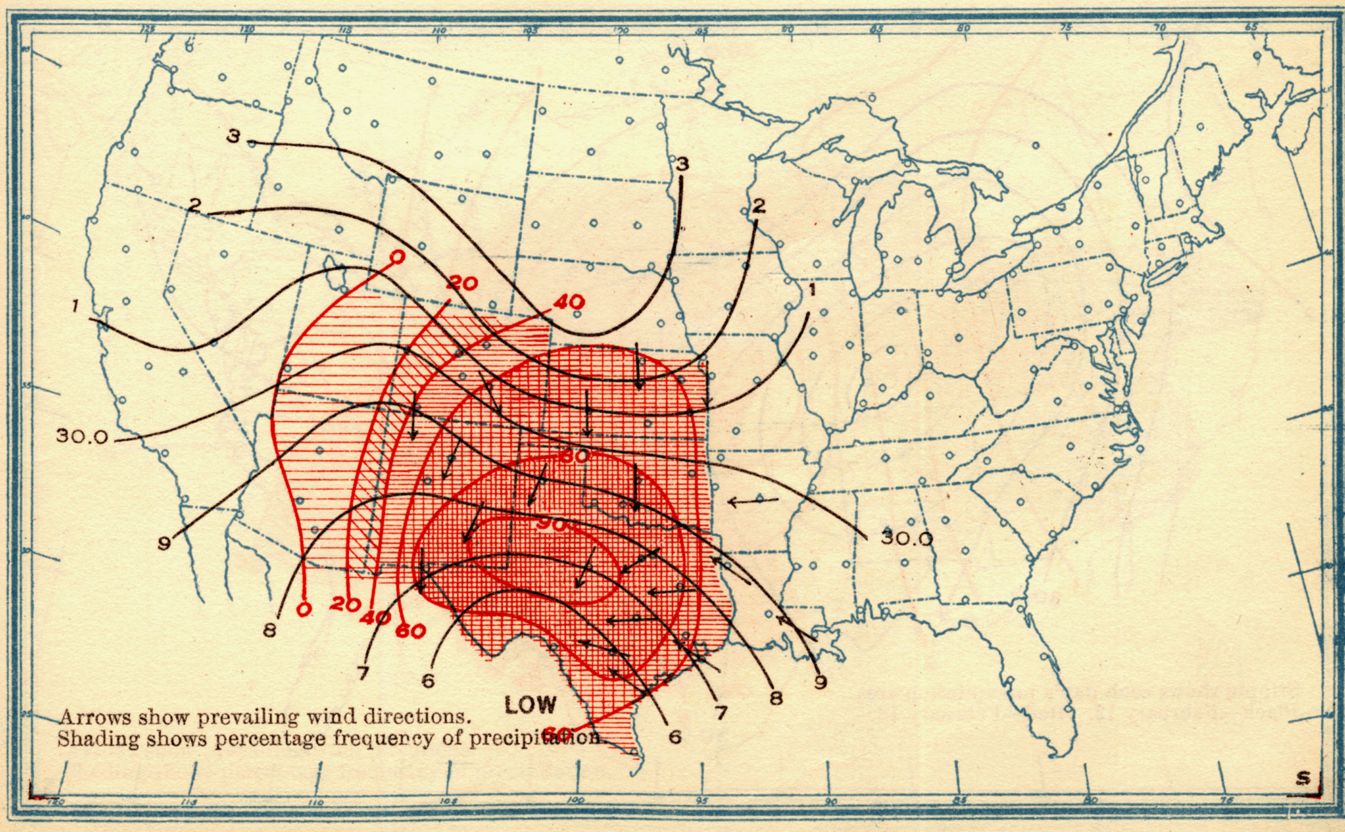

FIG. 5.—Composite of 8 LOWS with areas of greatest depression tangent to southeastern New Mexico.

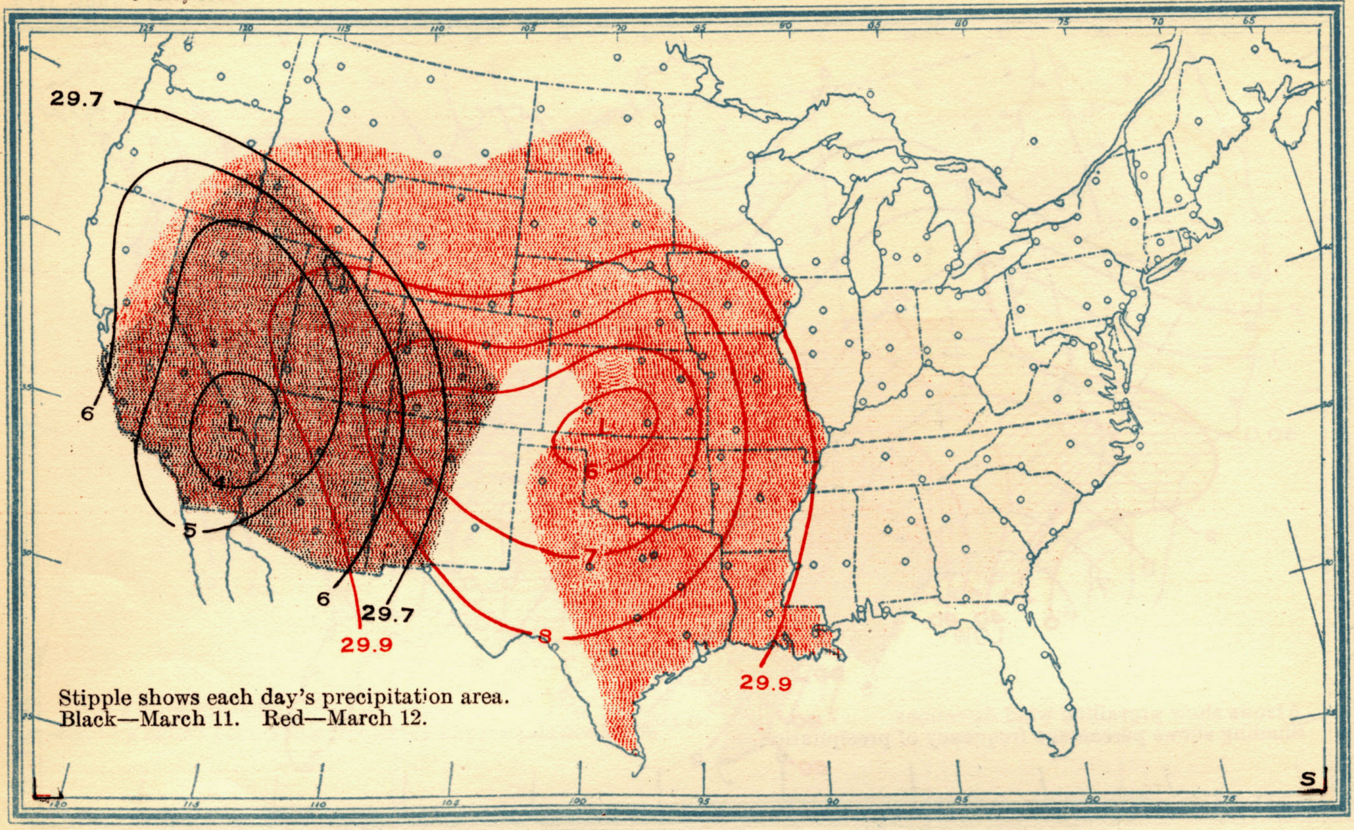

Fig. 6.—Combined pressure and precipitation maps of March 11 and 12, 1912.

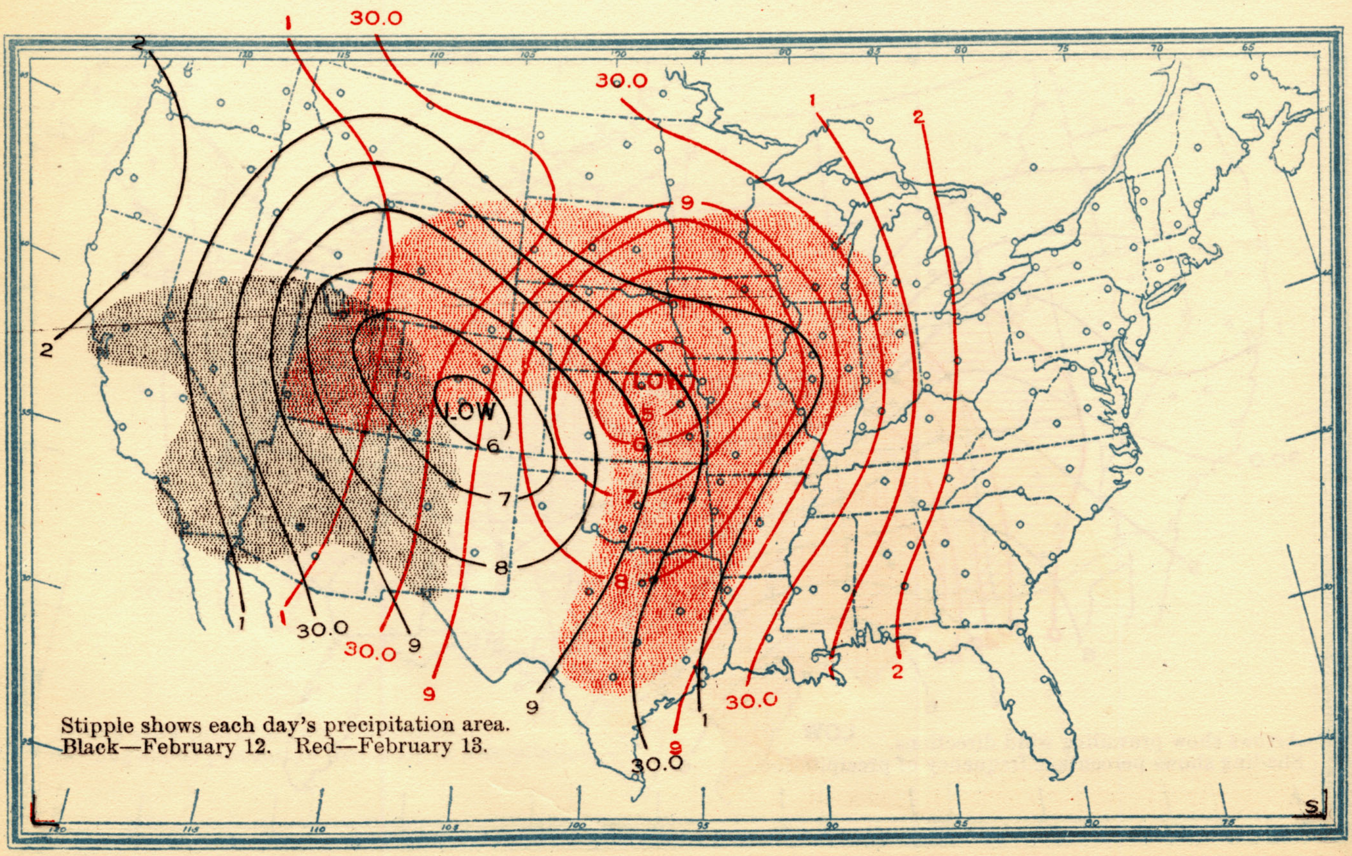

Fig. 7.—Combined pressure and precipitation maps of February 12 and 13, 1915.

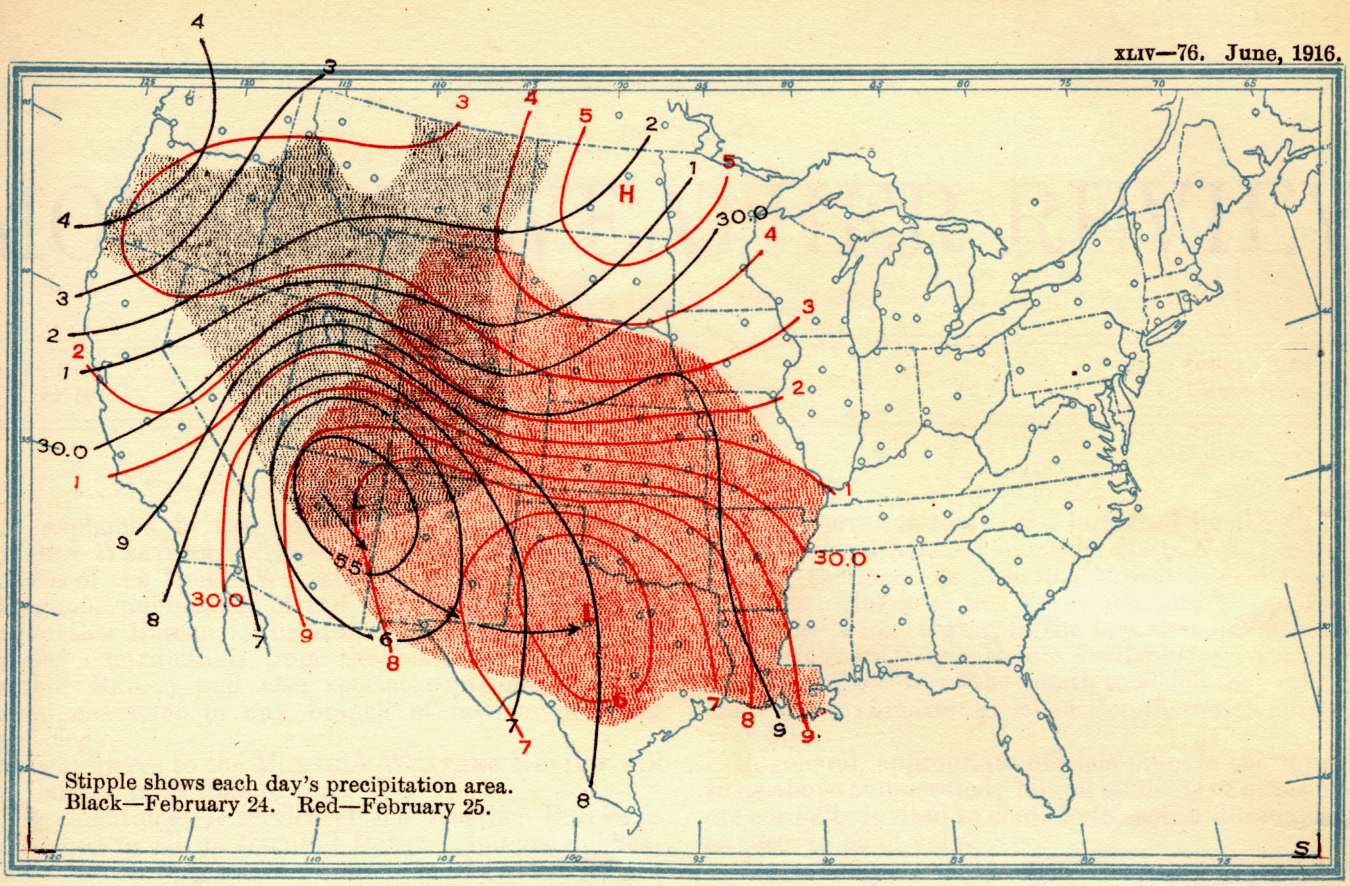

FIG. 8.—Combined pressure and precipitation maps of February 24 and 25, 1912.

The southeastward movement of the LOW produced precipitation over the "dry belt", which would not have occurred had the LOW followed the more usual path eastward.

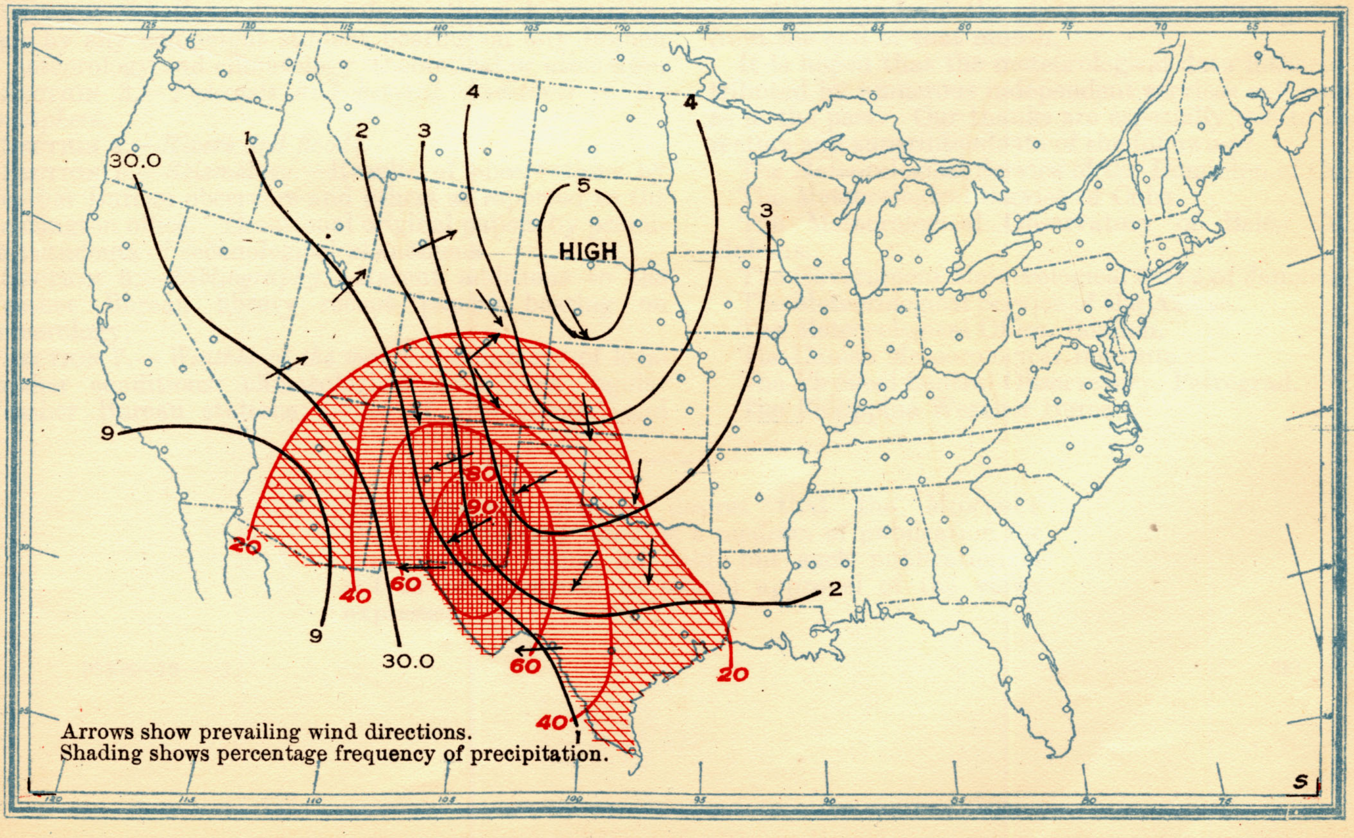

FIG. 9.—Composite of 14 HIGHS that produced precipitation in southeastern New Mexico.

tered near the northwest, northeast, southeast, and southwest corners of the State. It will be seen that the movement of a storm approximately along the northern border seldom produces precipitation over the "dry belt," while those that move along the southern border seldom fail to produce precipitation over the same area.

Of 16 LOWS that crossed the 105th meridian south of latitude 35°, 14 or 88 per cent produced precipitation over this region, while of 21 LOWS that crossed the 105th meridian between latitudes 35° and 40°, only 3 or 14 per cent produced precipitation over the "dry belt."

The late winter and early spring of 1912 furnished an unusually large number of the latter type of LOWS, there being no less than 10 of them within a three-months' period, all of which failed to cause precipitation over the region under discussion.

As illustrations, attention is invited to the weather maps of the following dates in the year 1912: February 20 and 24–25, March 2–5, 10–12, 13–14, and 20–24, April 19–20 and 27–28, and May 10–11. The storms of these dates caused general precipitation over their southeast and southwest, but missed the southern portion of the east mountain slope altogether.

One of these, the storm of March 11–12, is reproduced in connection with this discussion (fig. 6). It shows clearly this peculiarity in the precipitation area. A similar condition is illustrated in the combined maps of February 12–13, 1915 (fig. 7). With both of these storms the dry area extended northward into Colorado, but it was usually the case among the numerous types studied, that the dry area was somewhat more limited than this. The composite maps of the storms moving north of parallel 35 illustrate fairly well the average frequency of precipitation over this area and over the contiguous regions to the east, north, and west.

The combined maps of February 24–25, 1912 (fig. 8), give an example of a LOW being forced southeastward across New Mexico by incoming high pressure over the north, and producing general precipitation over the "dry belt," which would not have occurred had the LOW moved normally eastward. Compare the first position of this LOW (black of fig. 8) with the composite map of LOWS in that position (fig. 2); also with the LOWS of March 11, 1912 (black of fig. 6), and February 12, 1915 (black of fig. 7.)

Therefore the following general rule, applying only to the area under discussion, may be stated: *A storm area passing over or near New Mexico does not usually cause precipitation south of its center.*

Another condition that frequently produces precipitation over this region is a high-pressure area moving southeastward to Kansas or Oklahoma, preceded by southeast or east winds over this locality. The precipitation is generally light, and probably would not be of importance were it not for the fact that it occurs when conditions are strongly indicative of fair weather. When the incoming high-pressure area causes a large fall in temperature, precipitation may occur when the preceding humidity conditions are no more than normal. But usually it requires a preceding southeast or east wind, which seldom fails to increase the humidity over the region in question. Many such HIGHS cause overcast skies over southeastern New Mexico even when precipitation is absent.

A composite map of fourteen HIGHS, with their attendant precipitation areas, is here presented (fig. 9). In constructing this map, only such HIGHS as caused precipitation in western Texas or southeastern New Mexico were used. HIGHS of this class often bring about local rain in southeastern New Mexico when the skies are clear over the contiguous regions.

FOG IN RELATION TO WIND DIRECTION ON MOUNT TAMALPAIS, CAL.

By HERBERT H. WRIGHT, Assistant Observer.

[Dated: Weather Bureau, Mount Tamalpais, Cal., Feb. 15, 1916.]

The summit of Mount Tamalpais, rising to 2,600 feet above the Pacific Ocean within a distance of about 8 miles from the shore, possesses a distinct advantage for observational purposes over many other places that far exceed it in height. Owing to its proximity to so large a water surface it is specially suitable for observing and studying fog.[1]

Fog may be defined as visible particles of moisture floating in the atmosphere. In the vicinity of Mount Tamalpais fog usually occurs at an altitude of from 500 to 1,000 feet. It is therefore plainly visible from the Weather Bureau observatory near the summit of the mountain.

While fog occurs oftener and prevails for longer periods of time during the summer months, it occurs to some extent at all seasons. Table 1, compiled from records by the Weather Bureau on Mount Tamalpais, for the six years, 1910 to 1915, inclusive, shows the number of days in each month on which fog was observed in varying amounts below the elevation of the station. It will be seen from this table that the greatest percentage of fog occurs during the summer season.

TABLE 1.—*The number of days in each month on which fog was observed below the Weather Bureau station on Mount Tamalpais, Cal., 1910–1915, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days.*
1910	5	7	16	19	20	27	28	30	23	16	14	6	211
1911	0	4	7	13	9	26	29	27	19	11	11	6	162
1912	4	8	5	4	16	13	27	26	14	6	6	7	136
1913	5	10	14	16	22	25	27	25	17	16	10	12	199
1914	7	0	10	10	24	25	30	29	19	14	8	6	182
1915	5	2	6	11	18	25	26	26	20	20	12	7	178
Sums	**26**	**31**	**58**	**73**	**109**	**141**	**167**	**163**	**112**	**83**	**61**	**44**	**1,068**
Means	4.3	5.2	9.7	12.2	18.2	23.5	27.8	27.2	18.7	13.8	10.2	7.3	178

When a mass of air has been cooled to its dewpoint or lower, some of its invisible moisture condenses to form a visible cloud or fog. One of the various ways in which this cooling may be accomplished is that of the mixing of masses of air having different temperatures and relative humidities. In this process the character and the direction of the wind play a very important part. Entirely different conditions result when the warm air is driven out over the water to meet the cool air there than when the cool, moist air is carried shoreward, there to mix with the warmer air over the land. Mere direction alone, however, does not determine this; the character of the wind must also be considered. Fog very seldom forms when the wind is blowing from the east.

These east or northeast winds are not common along this coast, and occur only when a well-developed area of high pressure overlies Nevada and adjacent States. In the summer the air over the semiarid regions of Nevada and Utah becomes exceedingly warm and dry. Owing to the barometric gradient this warm, dry air flows down over California, and owing to the adiabatic heating often reaches the coast even warmer than when it started. Thus this air, under the influence of the east wind, goes out to mix with the cool air over the ocean, and being so dry has an enormous capacity for water vapor. The resultant temperature of the mixture is not low enough

[1] See the papers by *McAdie*, beautifully illustrated, in this REVIEW for 1900, 28: 283–6; 492–3; and 1901, 29: 24–5; 61–3; 104–6; and Weather Bureau bulletin "L".—C. A. jr.